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(54) Title: IMAGE PRODUCTION

(57) Abstract

Visible images are produced by directing pulsed or continuous wave laser radiation imagewise towards a substrate having thereon a plurality of continuous layers each having respectively different hues and/or reflection densities, so as to cause an imagewise distribution of discontinuities in the layers by ablation of respective selected portions of the layers, the distribution of discontinuities constituting the visible image. The substrate has layers comprising pigmented or photochromic material.

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Image Production

The present invention relates to the selective removal of coloured layers present on a substrate so as to form an image.

Most image-forming processes rely upon adding a pigmented material in a carefully controlled manner to a substrate, typically paper, to form an image. In the earliest known processes, a pigmented material is applied to a reversed embossed image which when pressed on to a substrate, typically paper, produced a desired recognisable pattern or image.

Subsequently more refined processes have involved the transfer of coloured materials, often in the form of a dot array, to substrates in order to form a coloured image. Typical of such processes are the ink-jet printing process, processes depending on electrostatic charges attracting pigments to a transfer drum, and the well established technique of photolithography.

All these techniques rely upon adding material to the substrate in a carefully controlled manner. This invention, on the contrary, provides a process where coloured layers, such as the primary colours, black and white may be applied to a substrate, typically paper, tinplate or aluminium in sequential continuous layers, which layers are selectively removed under carefully controlled conditions to expose desired colours in predetermined areas to form a visible image.

Scraper boards have been used in schools and by artists in a method of forming a pattern by removal of coloured layers present on a substrate of different colour, but the mechanical removal of such layers is very crude and incapable of operating at high tolerances.

According to the present invention there is provided a method of production of a desired visible image, in which laser radiation is directed imagewise at a substrate having thereon a plurality of continuous layers each having respectively different

hues and/or reflection densities, so as to cause an imagewise distribution of discontinuities in said layers by instantaneous ablation of respective selected portions of said layers, said distribution of discontinuities constituting said desired visible image.

The use of laser radiation in this way permits selective ablation of material from said layers in a predetermined pattern, at very high tolerances, the radiation being successively focused over a very small diameter to ablate successive shallow discontinuities (pits) in the layers on the substrate. If the depth of such pits is of the order of magnitude of the thickness of an adjacent layer, then the next coloured layer will be revealed. By tuning and/or programming the nature and energy of the laser radiation, it is possible to selectively reveal different layers, so as to generate a black and white or coloured image based upon the way in which the laser source is programmed.

The control of the energy supplied to each point on the respective layers may be achieved by irradiation with a series of rapid pulses of laser radiation, whose amplitude and/or duration determines the total energy emitted. Such pulses of radiation (sometimes referred herein to the "writing laser") may each have a duration of from 1 microsecond to 1 millisecond, typically with a wavelength 600 to 1500 nanometres.

Alternatively, continuous operation of the laser may be used in some embodiments to provide a constant output or constant average output of radiation energy, with imagewise control of the energy being achieved by varying the dwell time (which is the duration of time that the laser radiation impinges a predetermined portion of a layer). This imagewise control may be achieved by using a velocity modulated scan.

In a preferred method according to the invention, the image to be produced is divided into pixels and the hue and/or reflection density at each pixel predetermined by selection of the amplitude, duration or frequency of successive pulses of laser radiation. Each pixel corresponds to a desired pit or discontinuity.

In one embodiment, the substrate has thereon two or more pigmented continuous layers each having different hues or reflection densities. The energy absorption characteristics and composition of each layer are generally such that the amount of energy to form a pit by selective removal of a predetermined area element of the layer by ablation is constant across the layer.

In this embodiment, the lowest energy pulse of the writing laser will remove by ablation an element of the first pigmented layer so as to form a discontinuity or pit. If the energy is increased an element of the next layer is removed. Further increases in energy of the writing laser pulses will remove elements of any subsequent layers until finally the support is revealed.

In an alternative embodiment, the substrate has thereon one or more continuous layers each containing photochromic material dispersed therein (possibly in micro-encapsulated form). Each photochromic material changes hue or reflection density on receipt of a predetermined energy dose. The energy absorption characteristics and composition of each layer are such that the amount of energy to achieve a change of hue or reflection density through photochromic action in any given area element of the layer is constant. In the case of encapsulated photochromic dyes, a single layer having a mixture of capsules may be used, such capsules being activated in accordance with the energy and wavelength of the writing laser radiation.

The substrate may be paper, a synthetic polymer film or other material. Preferably the substrate either inherently has a high reflection density or carries a surface coating having a high reflection density. A high reflection density ensures, not only that the image formed has good highlights and contrast, but also that any radiant energy passing through the layers is reflected back to increase the absorption of energy and efficiency of the image production process.

Each layer may be coated uniformly and in a continuous manner on the substrate by conventional coating techniques such as silk screen coating, micro gravure coating, kiss coating, hopper coating and vacuum deposition.

Methods of scanning surfaces with laser beams are well known using mirrors, Faraday effect elements, and similar radiation diversion means. The writing laser may be a continuously operating laser, such as a gas laser, a liquid laser or a semiconductor laser. Carbon dioxide lasers and YAG lasers are particularly useful. Tunable lasers may be used to selectively direct energy into appropriately absorbent layers.

Raster scanning of the substrate may be achieved by two dimensional movement of a laser beam across a stationary sheet, or by a line scan while moving the substrate. While the image is being formed by ablation, the irradiated surface may be blown to eliminate ablated particles and prevent settlement on the surface.

The thickness of the various layers on the substrate will influence the amount of energy which is required to ablate material and produce the required image. The thinness of the coat will be limited by the accuracy of the laser beam in penetrating to a specific depth to expose the required pigment. The use of photochemical, as opposed to photothermal, techniques would reduce the power required to produce the surface pattern. In one aspect of the invention, therefore, photochromic pigments are present on the substrate such that their appearance can be changed by exposure to visible laser light.

If the thickness of successive layers on the substrate is of the same order of magnitude as the diameter of the pit created by the laser radiation then the colour of the bottom of the pit cannot be seen at angles of view less than 45° to the surface. Tilting of the surface would therefore produce an extinction of the pattern produced by an array of laser etched pits and the principle could provide a system for securing evaluation of a product produced from the multi-layered coated substrate.

A specific embodiment of the invention is now described with reference to the following drawing.

Figure 1 shows an exemplary method according to the invention, in which a laser radiation source 1 directs laser radiation toward a first layer 2 of the substrate and thereby ablates a pit or discontinuity 4 in the layer 3. The depth of the pit or discontinuity 4 is of the order of magnitude of the layer, so as to reveal the coloured layer below. The pit or discontinuity may be of a size corresponding to one pixel.

Depending on the power of the laser radiation, the pit may be formed in one layer (as shown), two layers or more. The laser beam is caused to scan (by means not shown) over the surface of the substrate in a predetermined manner such that the resulting image depends on the zones ablated, and the respective depths of the pits at each point.

Claims:

1. A method of production of a visible image, in which laser radiation is directed imagewise at a substrate having thereon a plurality of continuous layers each having respectively different hues and/or reflection densities, so as to cause an imagewise distribution of discontinuities in said layers by substantially instantaneous ablation of respective selected portions of said layers, said distribution of discontinuities constituting said desired visible image.

2. A method according to claim 1, wherein said portions of said layers are ablated in a predetermined pattern.

3. A method according to claim 1 or 2, wherein said laser radiation is focused so as to ablate a series of said discontinuities in the form of pits in successive layers.

4. A method according to any of claims 1 to 3, wherein said laser radiation is pulsed, each pulse having a duration of 1μs to 1ms and having a wavelength in the range of 600nm to 1500nm.

5. A method according to any of claims 1 to 3, wherein said laser radiation is continuous wave.

6. A method according to claim 5, wherein a velocity modulated scan controls the energy of said laser radiation.

7. A method according to any of claims 1 to 6, wherein said laser radiation is provided by a tunable laser source programmed to selectively ablate different ones of said layers.

8. A method according to any of claims 1 to 7, wherein said image is divided into pixels, the hue and/or reflection density at each pixel being predetermined by selection of the amplitude, duration or frequency of successive pulses of laser radiation.

9. A method according to any of claims 1 to 8, wherein each of said layers comprises a pigmented layer.

10. A method according to claim 9, wherein each successive rise in energy produces a respective discontinuity in each successive one of said layers.

11. A method according to any of claims 1 to 8, wherein each of said layers contains photochromic material.

12. A method according to claim 11, wherein said photochromic material is in encapsulated form, in which at least one said layer comprises a mixture of capsules.

13. A method according to any of claims 1 to 12, wherein substantially the same energy of said laser radiation is applied to each said layer.

14. A method according to any preceding claim, wherein said substrate has a reflective surface.

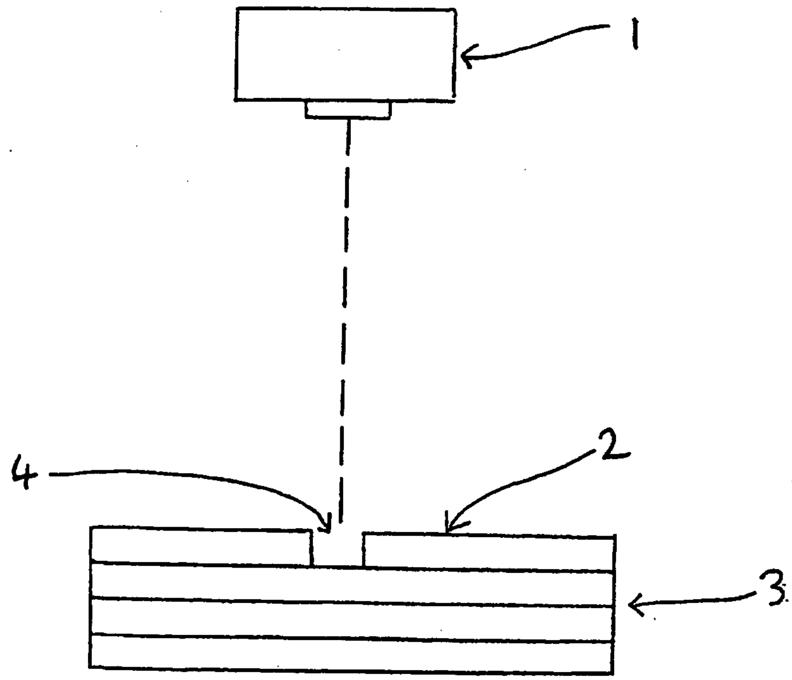

FIG. 1

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B41M5/24 G03C7/00 G03C1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B41M G03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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